Experiment Operations Overview

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BNL S&T Review 2016, August 23, 2016

BROOKHAVEN NATIONAL LABORATORY

a passion for discovery

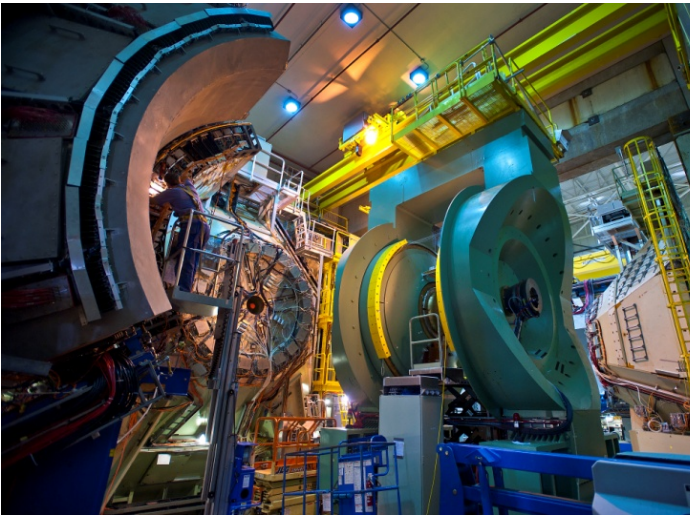
U.S. DEPARTMENT OF ENERGY | Office of Science

Outline

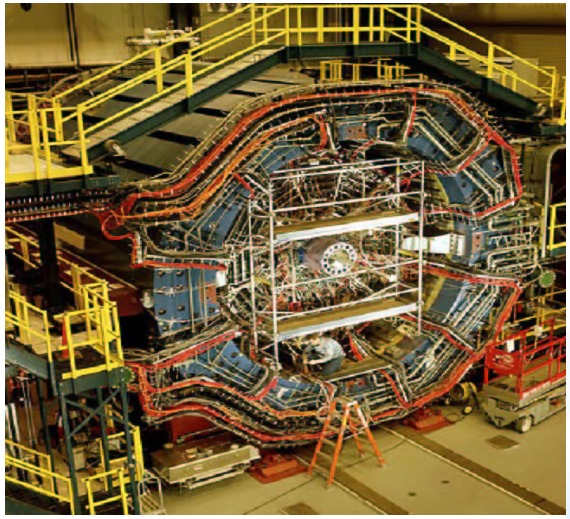
- Successes and challenges of recent detector upgrades
- Detector operations task force
- iTPC upgrade: resource and schedule challenges
- Transition to sPHENIX
- Data backlog: challenges and strategies
- Experimental support staffing levels

Scope of Detector Operations

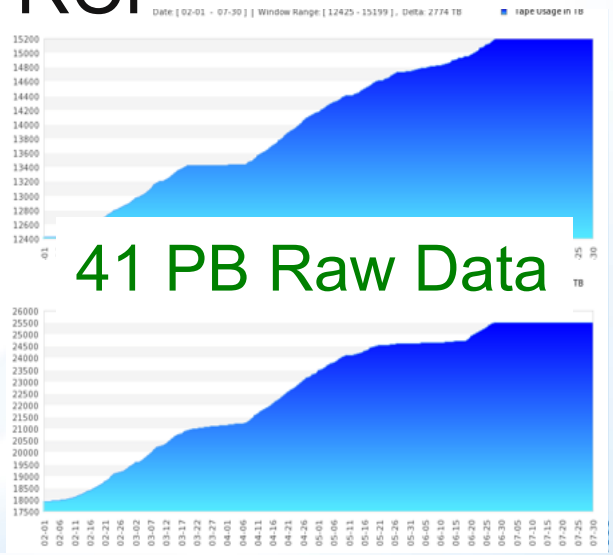
PHENIX



STAR



RCF



Provide operational support for RHIC experiments, and ~95% of computing needs for processing

Upgrades for detectors:

MIE, Capital Equipment, and minor upgrades

Successes of Detector Upgrades

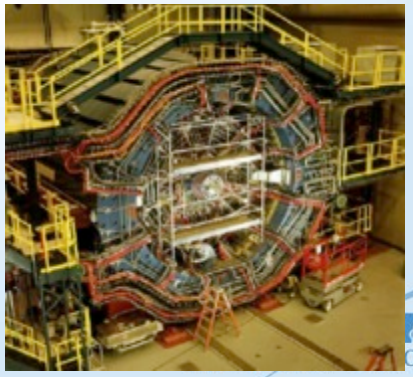
RHIC-II Detector Upgrades:STAR

★ MIE CE Cap. Equip. Ch China funds In Indian contribution Fr French contribution Ru Russian contribution

		Built	Operational
★ Ch	Time of Flight (TOF) $4.8M	FY 06-09	Run 10
CE	DAQ 1000 $1.8M	FY 06-08	Run 9
Ru CE	Forward Meson Spectr. (FMS) $0.8M	FY 06-08	Run 8
CE	Forward Gem Tracker (FGT) $2M	FY 08-12	Run 13
Ch In CE	Muon Telescope Det. (MTD) $1.8M	FY 12-14	Run 14
Fr ★	Heavy Flavor Tracker (HFT) $14.2 M TPC (orig. $16.7 M)	FY 11-14	Run 14

Complete; Operating for physics

These upgrades have brought STAR from a low-rate tracking detector as originally designed to a high-rate detector with large-solid-angle capability for strange, charm and bottom particle detection, as well as forward-angle detection of hadrons and $W^{\pm}$ decays, at full RHIC-II luminosity.



RHIC-II Detector Upgrades:PHENIX

★ MIE ★ NSF-MRI

CE Cap. Equip.

Ja Japan funds
Fr French contribution
Sk South Korean

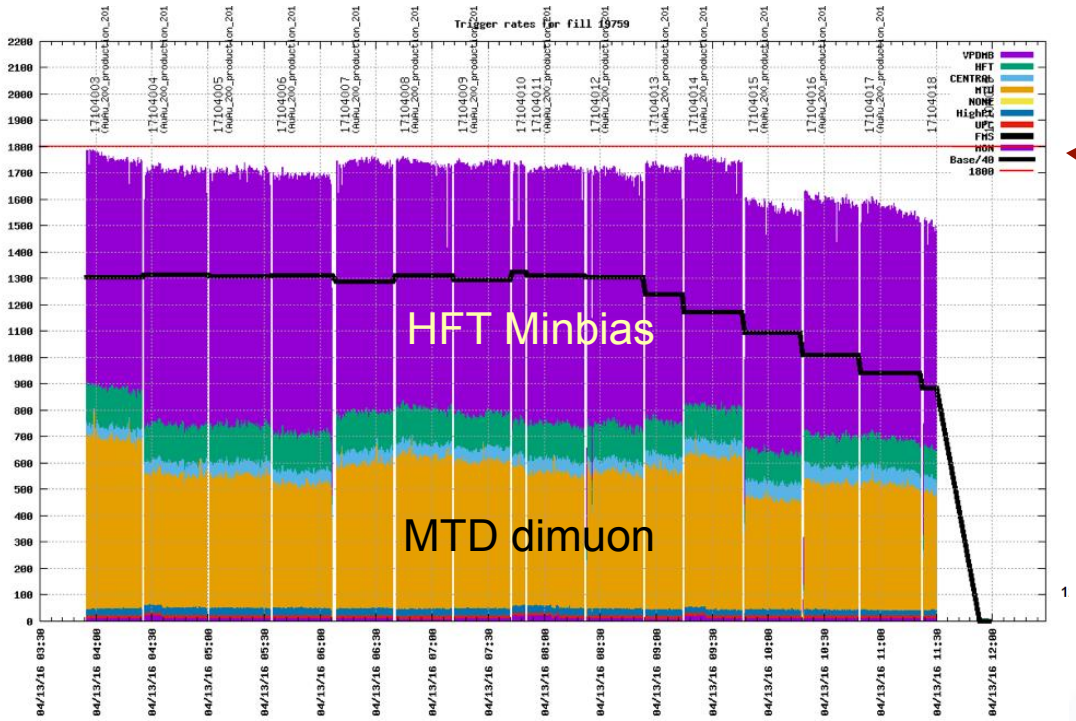
			Built	Operational
CE	Hadron Blind Detector $1.2M	Physics run complete	FY 05-09	Run 10
Fr ★ Ja	Si Vertex Tracker (VTX) $4.7M	Complete; Operating for physics	FY 07-11	Run 11
★	Forward Vertex Tracker (FVTX) $4.9M		FY 08-12	Run 12
★ Ja	Muon Trigger $4.3M		FY 07-11	Run 12
Sk	MPC-EX $1.0M		FY 12-14	Run 15

These upgrades give PHENIX :

- **A unique look at background-suppressed low-mass e-pairs.**
- **The capability to exploit RHIC-II luminosities with the measurement of identified heavy flavor production in HI collisions, flavor-identified sea-quark contribution to the proton spin via $W^{\pm}$ decay in 500 GeV p-p collisions, and identified forward photons in p-p and d/p-Au collisions.**

Design longevity: DAQ1000

Capital Equipment: $1.8M



2 kHz speed limit from Gating Grid

Design has stood the test of time extremely well

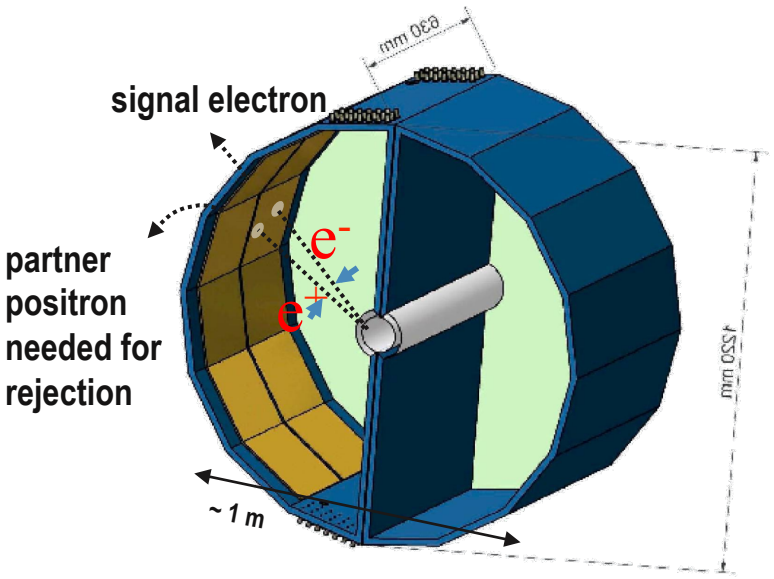
With minor reconfigurations: Gating Grid, and not the Data Acquisition system, is now the speed limit

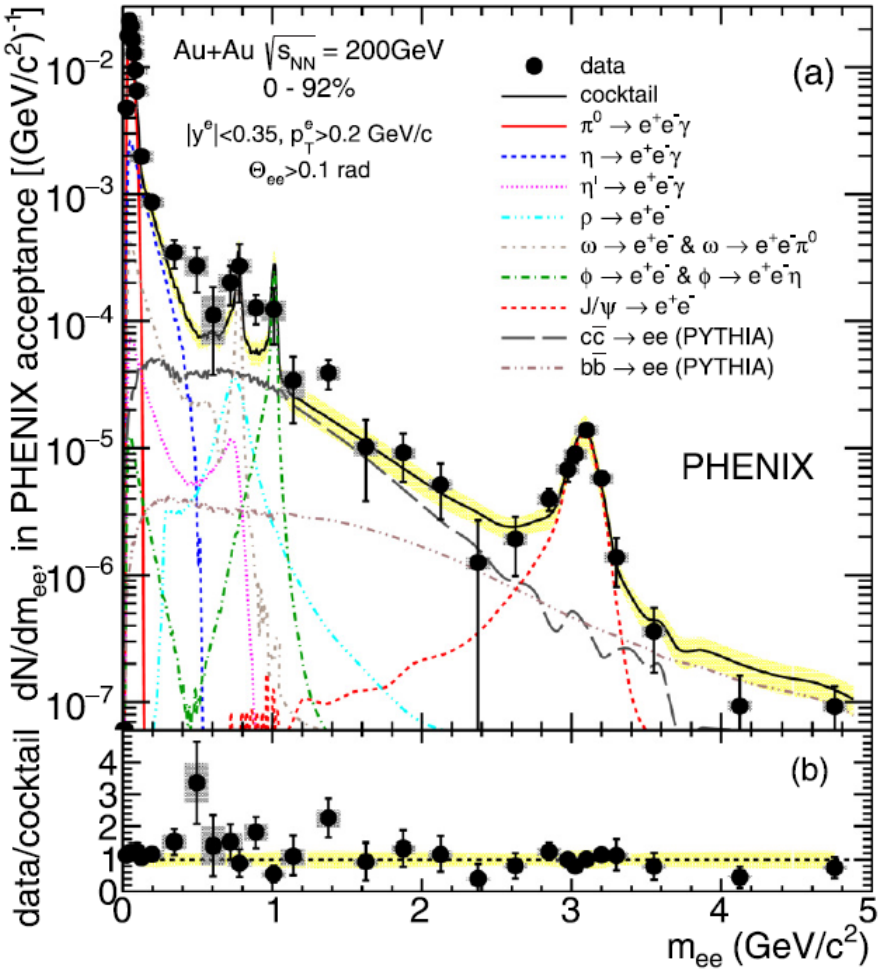
Same model (adaptation of ALICE chips to STAR) used for iTPC

Hadron Blind Detector

Capital Equipment: $1.2M

Phys. Rev. C 93, 014904 (2016)





Goal: increase precision of low-mass dielectrons

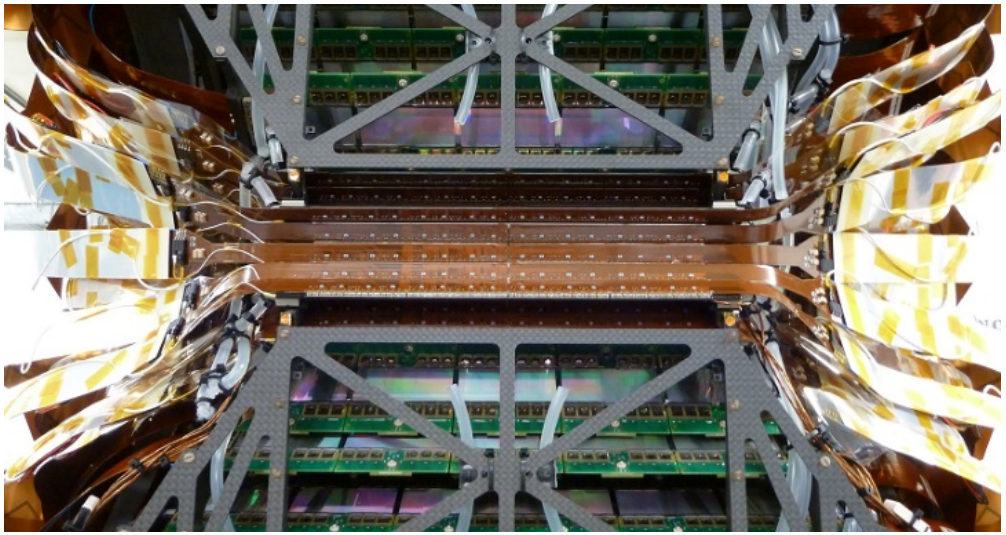
Resolve PHENIX/STAR discrepancy

2016: Publication of measurement

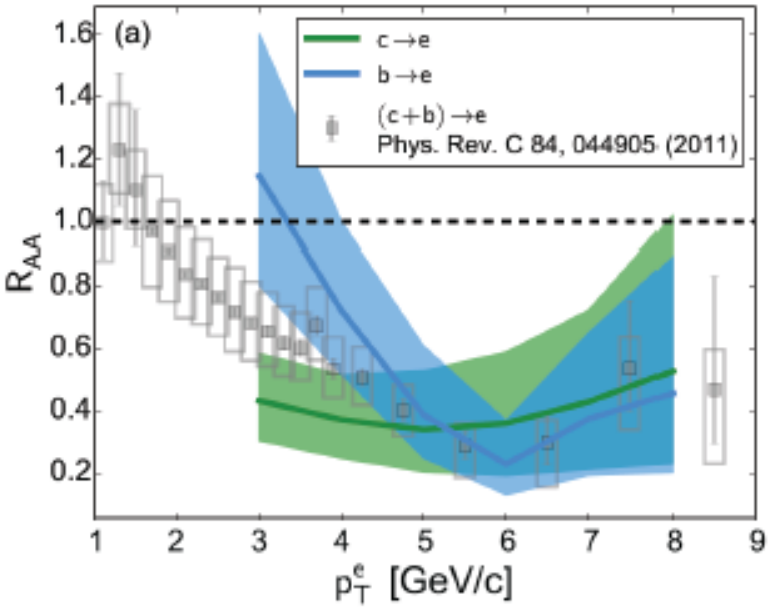
Goals achieved: removed 2011

PHENIX VTX

MIE: $4.7M



Phys. Rev. C 93 (2016) 034904



Goal: separate charm from beauty in semileptonic decays

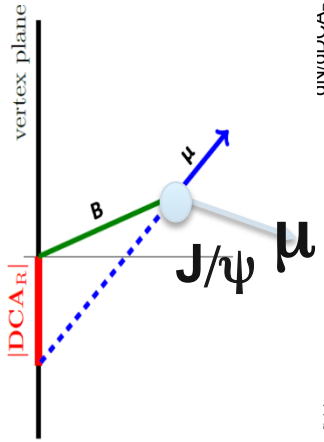
2016: Published first measurement from 2011

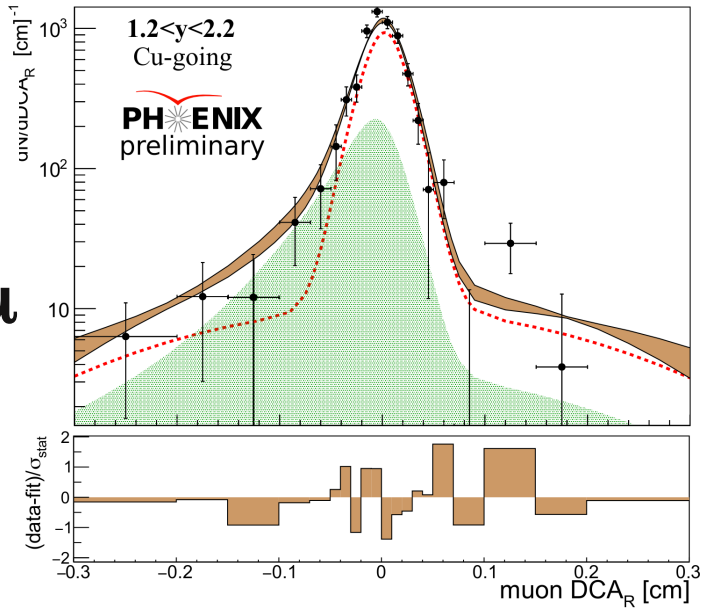
Major improvement in precision Runs 14-16

Goals achieved: in process of removal

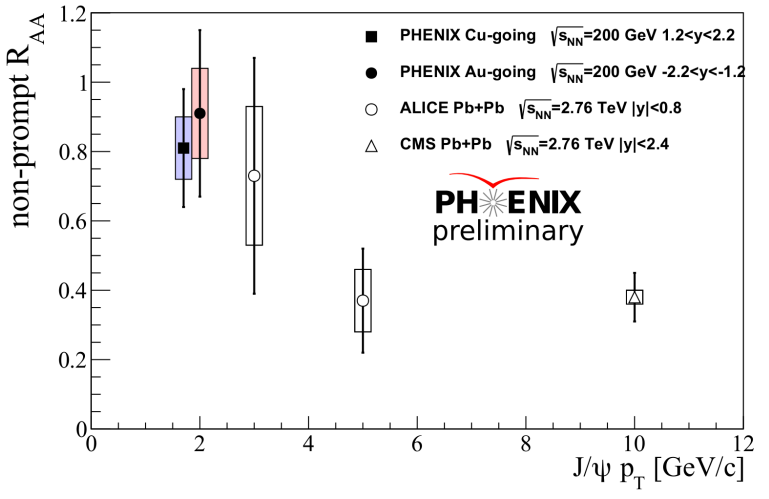
PHENIX FVTX

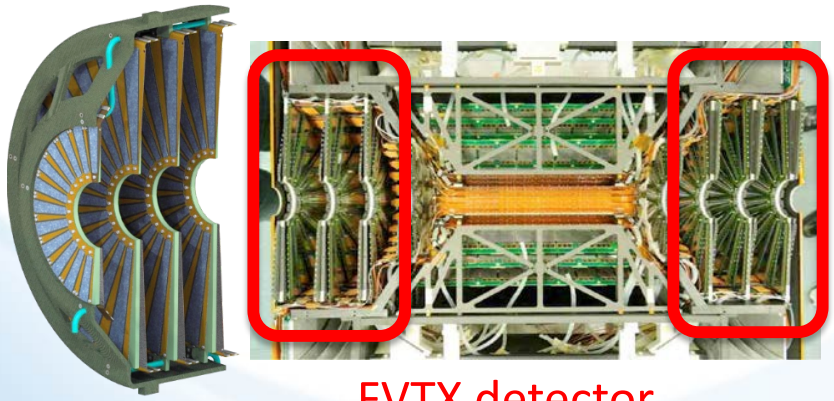
MIE: $4.9M





$$R_{AA}^{B\to J/\psi} = \frac{F_{B\to j/\psi}^{AA}}{F_{B\to j/\psi}^{pp}} R_{AA}^{J/\psi} = \frac{F_{B\to j/\psi}^{AA}}{0.1} R_{AA}^{J/\psi}$$



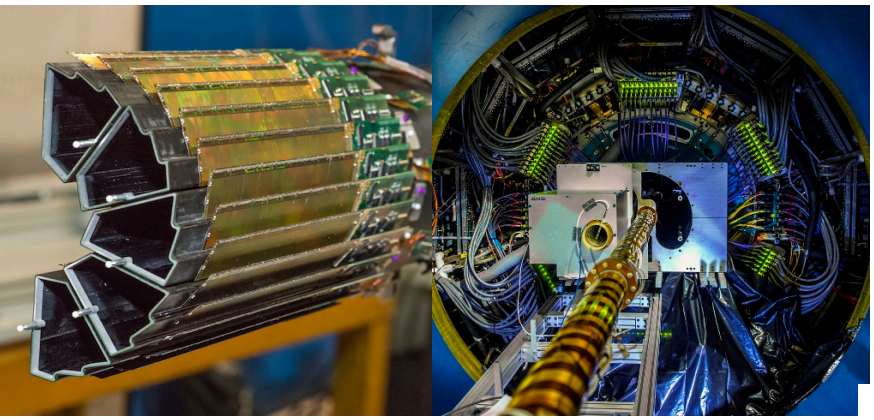


FVTX detector

- Goal: improve quarkonium precision
- Results available: first direct B → J/Ψ
- Critical to Run 16 d+Au energy scan
- Goals Achieved: in process of removal

STAR Heavy Flavor Tracker

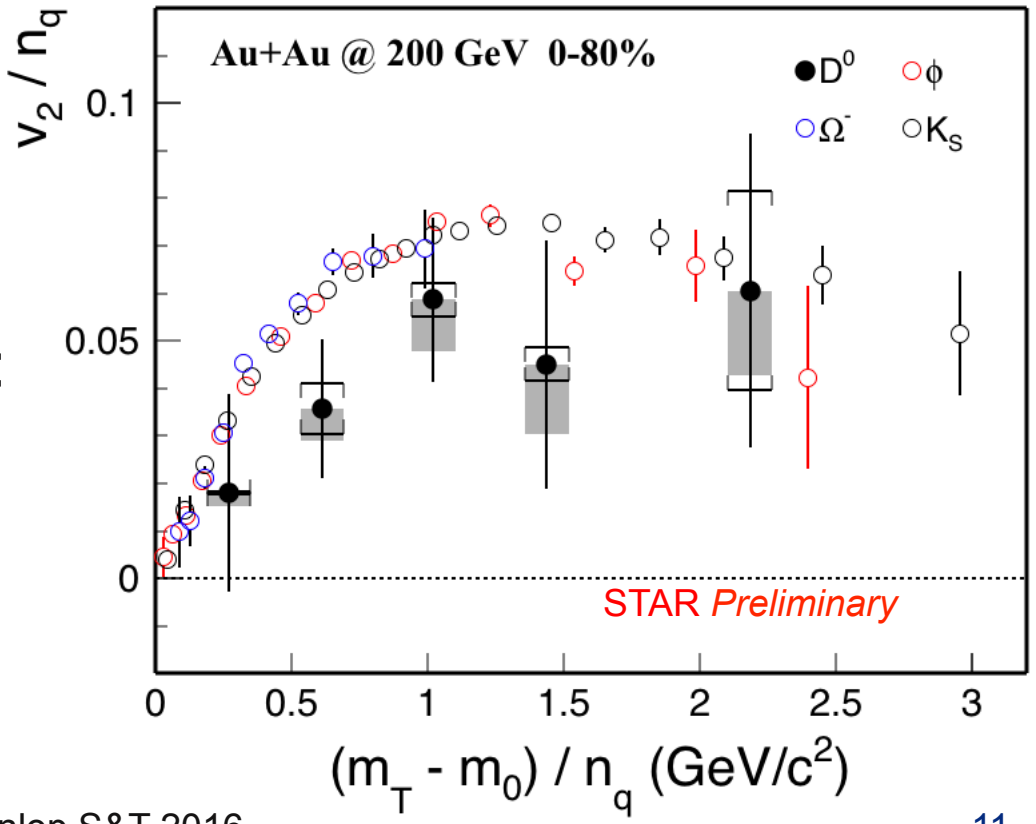
MIE: $14.2 M TPC



First use of Monolithic Active Pixel Sensors in a collider environment

Finished under budget and ahead of schedule

Presented at QM2015



Does charm flow?

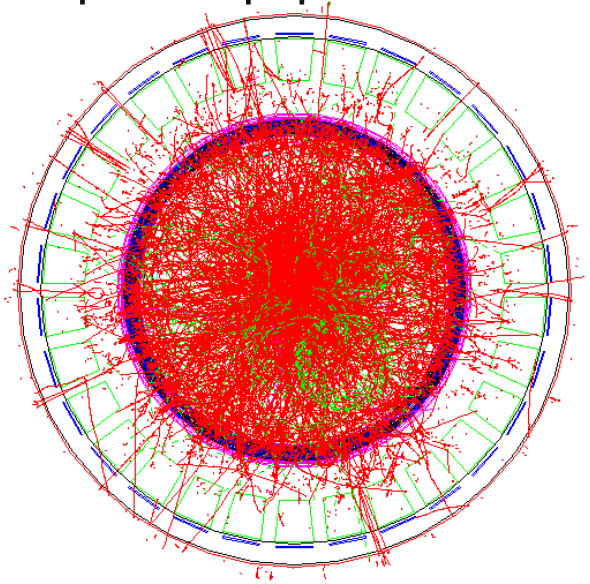
Yes

Run 16 met goals of proposal: major precision improvement and likely Λ_c

Goals achieved: in process of removal

STAR Muon Telescope Detector (MTD)

Capital Equipment: $1.8 M



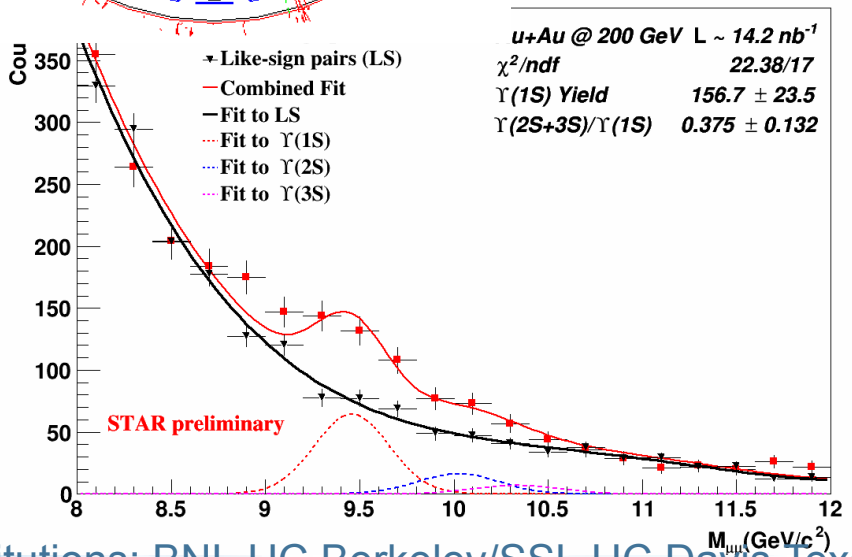
Muon Tagger: use the magnet steel as absorber, TPC for tracking

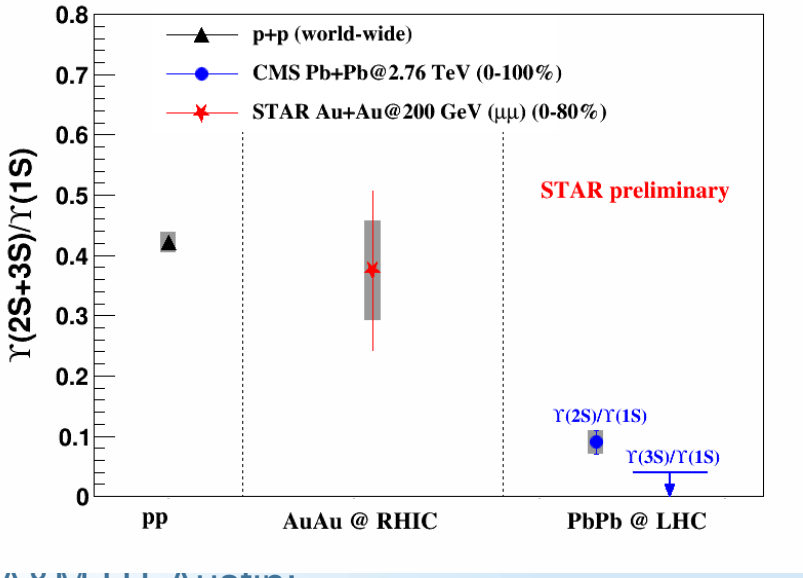
Goal: Separate Υ(1S) from excited states

First results presented from Run 14

$\mathcal{L}_{integrated}$:20 nb^{-1} Runs 14+16, as proposed

Will remain installed

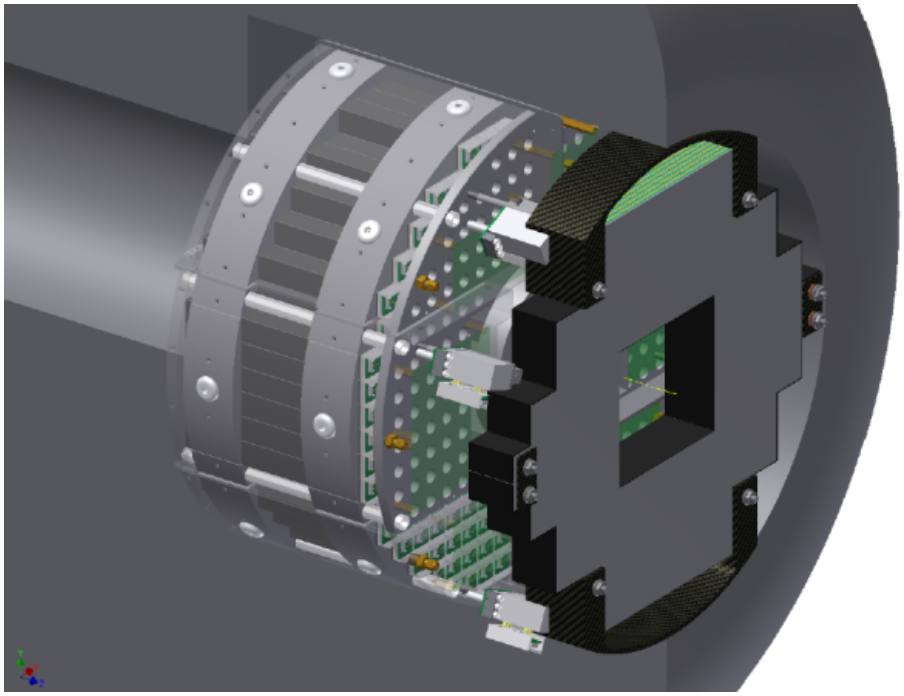


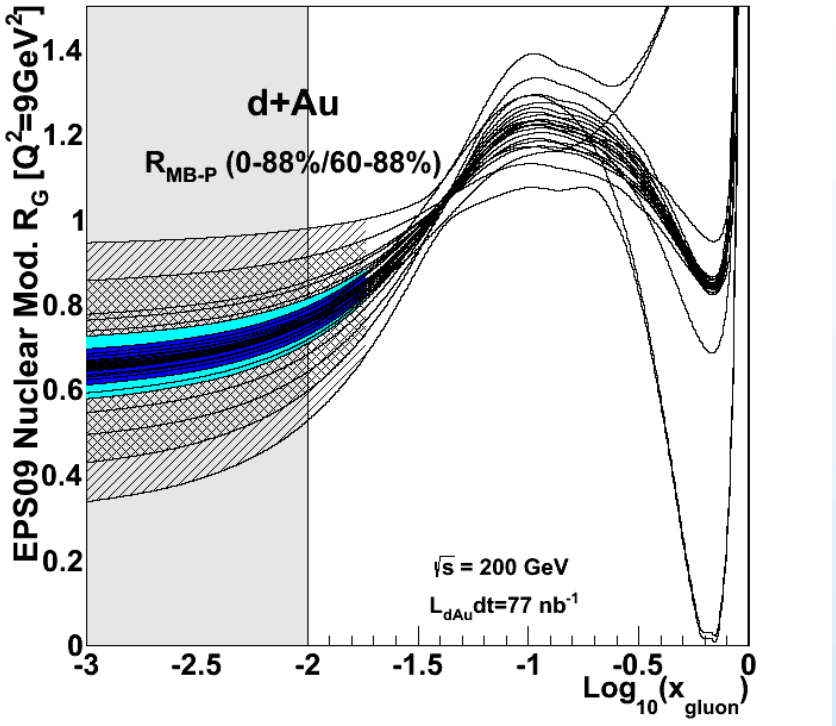


Institutions: BNL,UC Berkeley/SSL,UC Davis,Texas A&M,UT Austin; China: USTC,Tsinghua; India: VECC

PHENIX MPC-EX

Capital Equipment: $1.0M





Goal: direct photon identification for A_N and R_{pA}

Issues in Run 15 configuration

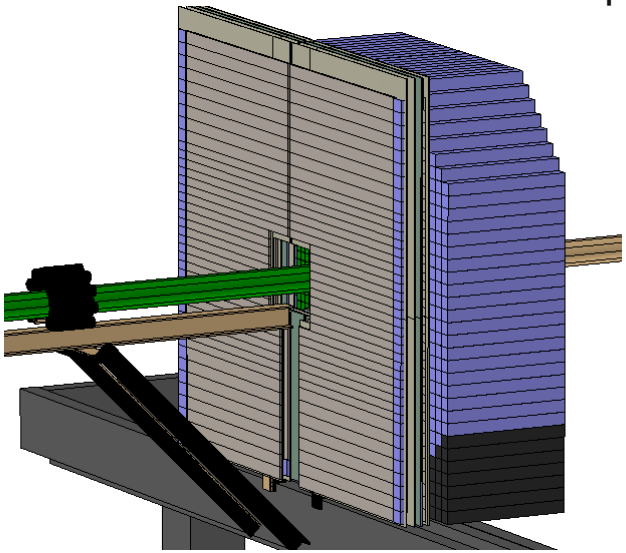
Successful Run 16 to recover some physics goals.

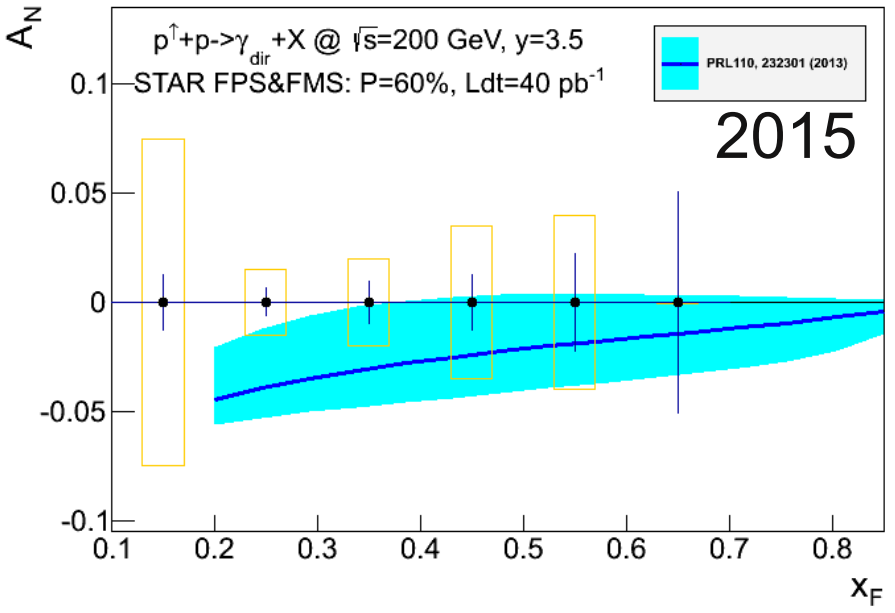
Complete. In process of removal

STAR Forward Preshower

Operations/R&D: $150k

building on 2008 $0.8M Capital Equipment investment in the Forward Meson Spectrometer





Goal: direct photon identification for A_N and R_{pA}

First large-scale use of SiPM in RHIC environment

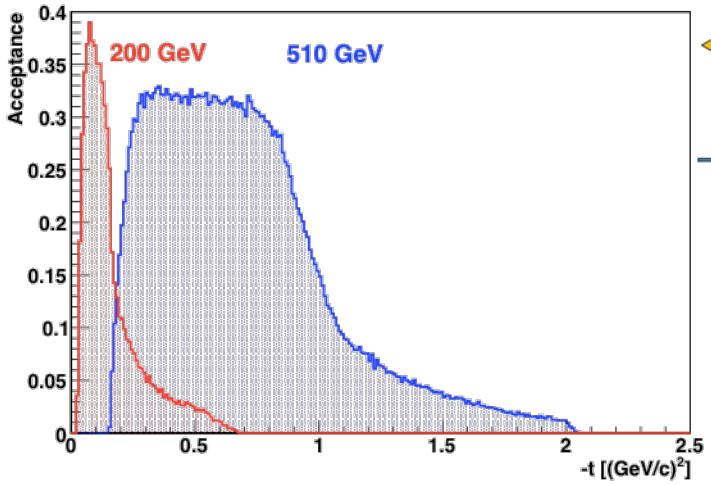
Critical R&D for sPHENIX and EIC

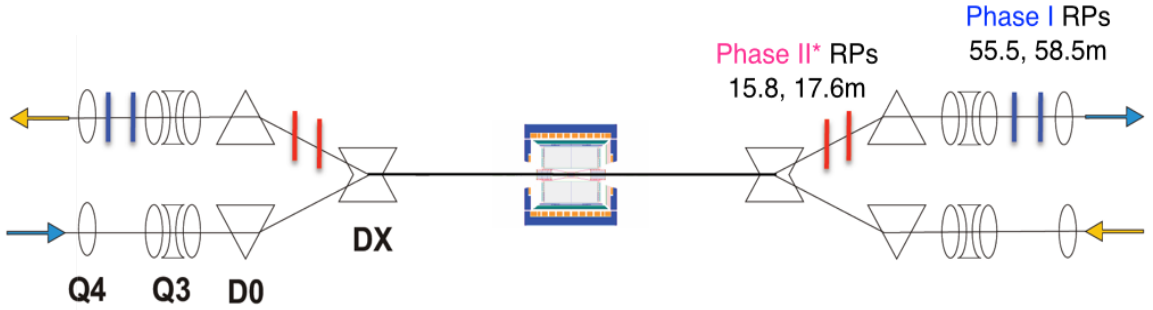
Risk mitigation: similar performance to goals of PHENIX MPC-EX

Successful Run 15: to be used in Run 17

STAR Roman Pots Phase II*

Operations: $345k





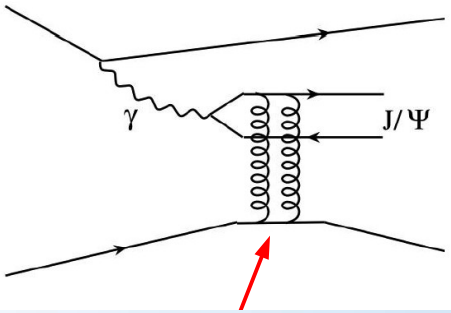
Tag protons at low t in p+p and p+A

Concurrent operation

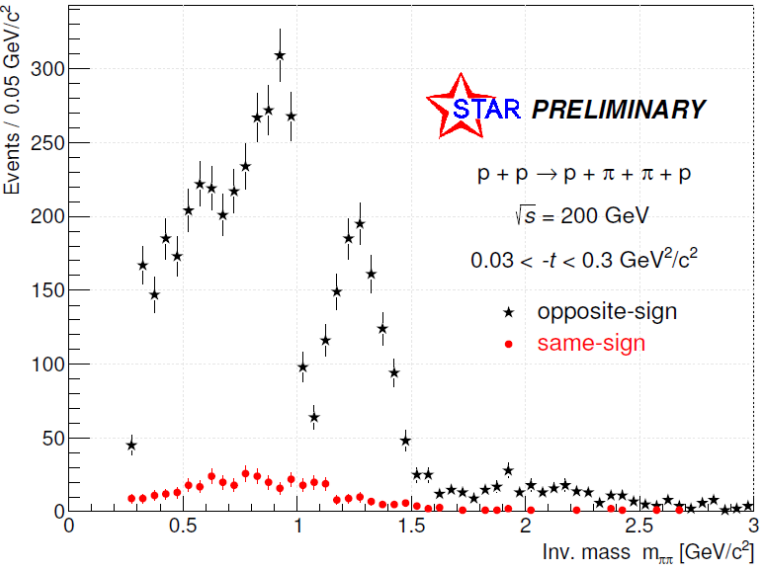
High luminosity

Physics goals:

- Exotic states
- Diffractive tag
- Possible: first look at GPD E_g



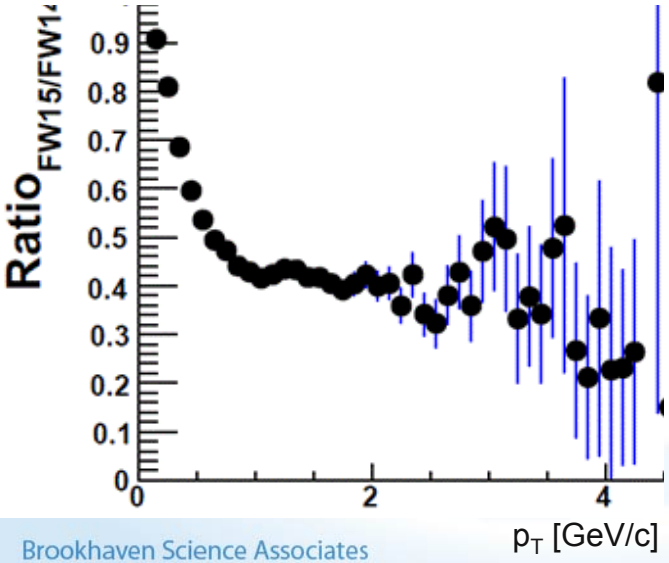
Successful Run 15: to be used Run 17



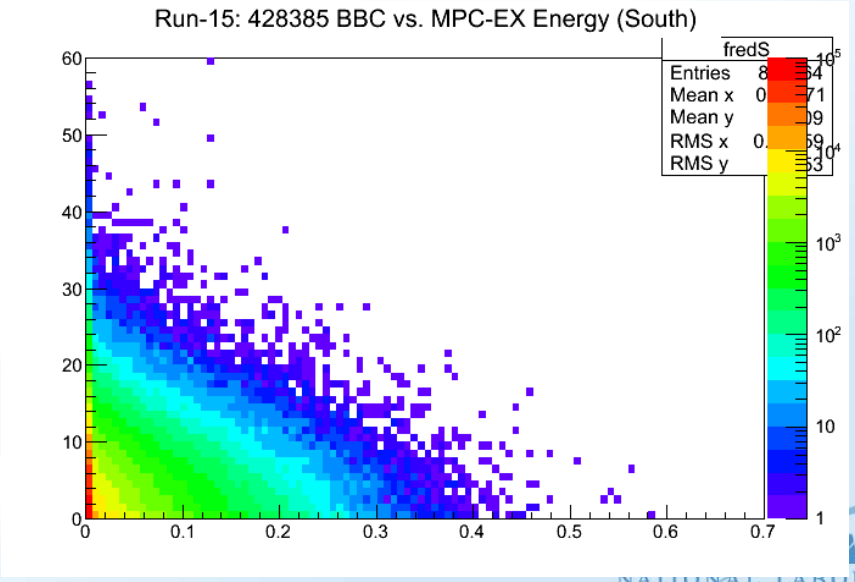
Challenges of recent detector upgrades

- STAR HFT and PHENIX MPC-EX: major issues in operational configurations during RHIC Run 15
  - MPC-EX: mismatch between firmware delay and the rest of PHENIX, leading to complete loss of ability to correlate data from this detector to the rest of PHENIX
  - HFT: major loss of efficiency due to change in firmware between Runs 14 and 15. Reverted partway through Run 16.

Relative HFT Efficiency Run 14/15



Correlation between PHENIX MPC-EX and BBC



Detector Task Force

- Commissioned task force of experts to investigate operational processes in place during RHIC Run 15 and recommend changes to practices
  - Formed Apr. 16, 2016. Report released to DOE May 24, 2016.
  - STAR and PHENIX experts and HEP members of the BNL Physics Department
    - Michael Begel [ATLAS] and Laurence Littenberg [history of QA on E787]

- While end effect similar, root causes different between STAR and PHENIX
  - PHENIX: rush to commission a new detector while run was ongoing
    - New and untested firmware and software was used for commissioning that needed to be revised as hardware problems were being worked through and the run was ongoing
    - An uncalibrated detector at run start that made quantitative evaluations difficult
    - An untested and unverified understanding of the detector element to electronics channel mapping generated confusion
    - Unexpected and unplanned-for electronics problems with the SVX4 front end chips and associated RDO chain
    - Unanticipated and unrelated issues from beam loss, diverting attention of the detector team
    - Configuration parameters for the detector that were not recorded run by run during the commissioning period, making it difficult to retroactively track changes in detector performance
  - STAR: tests in place to test firmware changes inadequate to find the issue
    - Efficiency loss incorrectly attributed to calibration issues or issues in the tracking algorithm

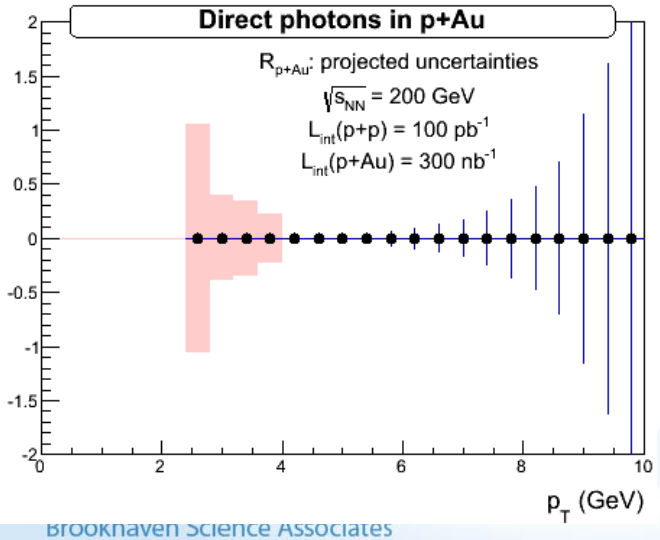
Detector Task Force: Proposed Practices

- Plan sufficient detector commissioning time
  - Time for detector commissioning with a sufficiently long prototype/commissioning period, up to and including an entire RHIC run, should be added appropriately to any new detector construction project. For this commissioning period, a significant portion of the new detector system should be in place, with its readout fully integrated into the experiment, along with a complete suite of monitoring processes.
- Develop sufficient software ahead of time
  - Online and offline software frameworks should be in place prior to detector commissioning, at minimum to the extent that they allow for meaningful testing of correlations with other detectors
- Archive all changes
  - Firmware and software used in detector system hardware configuration and readout must be archived and versioned for all running configurations in a code management system (CVS, SVN, etc.) Parameters used as input to the firmware must also be archived with a method appropriate for complete retrieval at a later date.
- Full testing of changes
  - All changes to the detector operation firmware/software need to be fully tested through a suite of regression tests in a full hardware/firmware/software environment that can be configured to demonstrate complete required functionality.

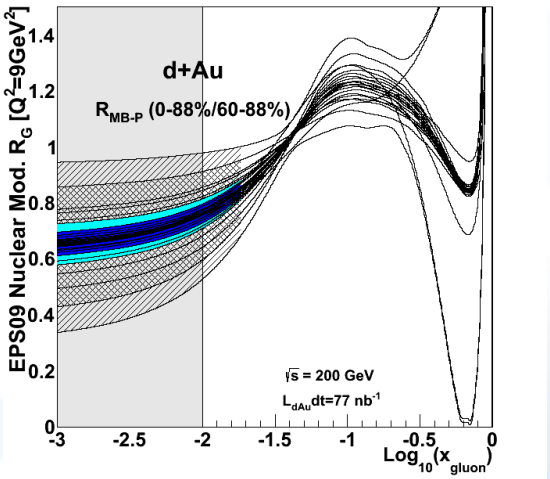
Physics Mitigations for Run 15: Redundancy

- HFT: Redundant methods for charm/beauty
  - Signal to Background high in p+p and p+A
    - Combinatoric reconstruction of D^0, as in Phys. Rev. D 86 (2012) 072013
    - J/Ψ – hadron correlations for B, as in Phys. Lett. B **722** (2013) 55
- MPC-EX: Detector and colliding system redundancy
  - Run 15 p+p and p+A: STAR FMS Preshower
  - Run 16 d+Au: MPC-EX + luminosity improvements

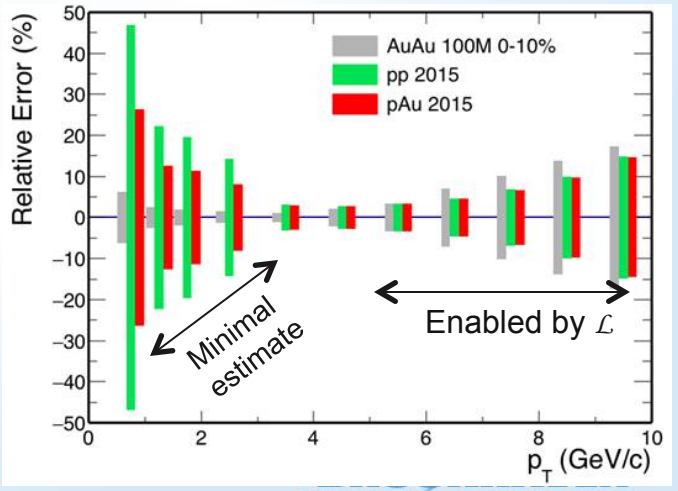
Run 15: STAR FMS Preshower



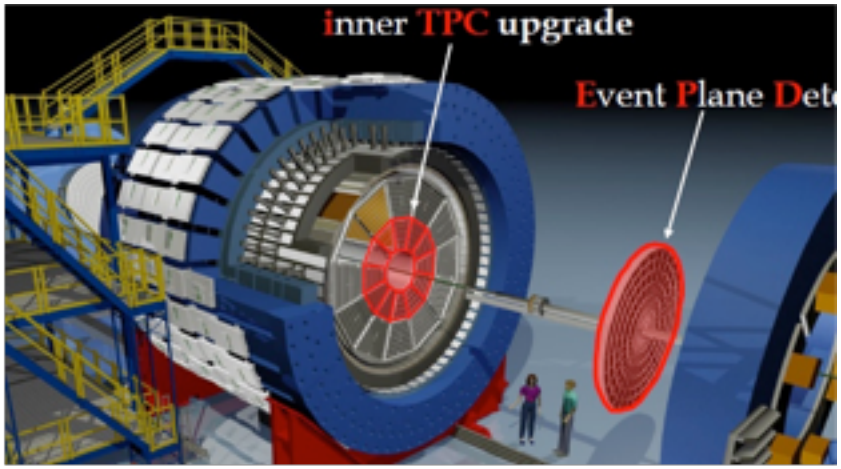
Run 16: PHENIX MPC-EX

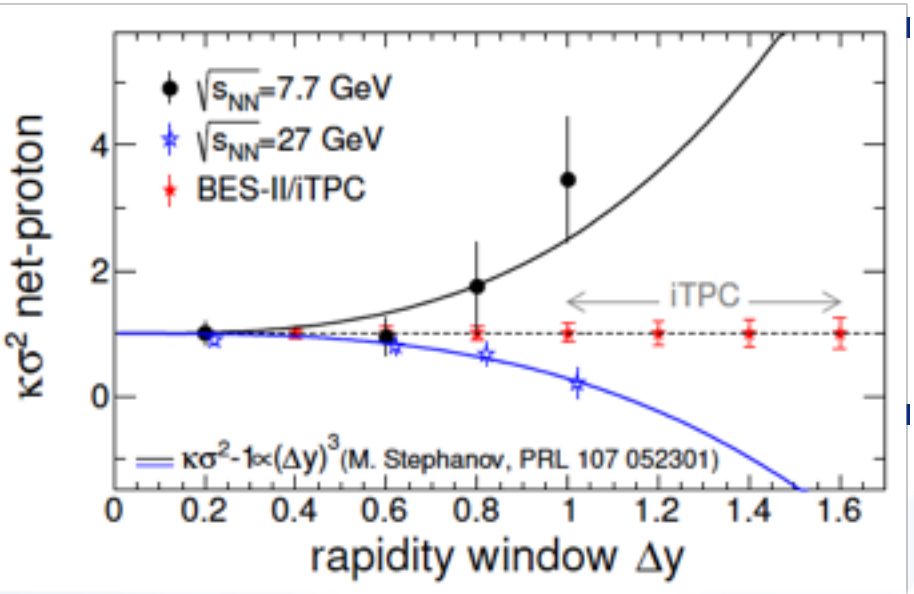


Run 15: D^0 without HFT



iTPC Upgrade





Goal: robustness of critical signatures for BES-II

Schedule: Feb 2016-March 2019

Cost: $3.6M Capital Project + contributions from China

- $1.2M/year FY16-FY18 from Capital budget for RHIC Detectors

Main concern is with the schedule: reasonable but tight

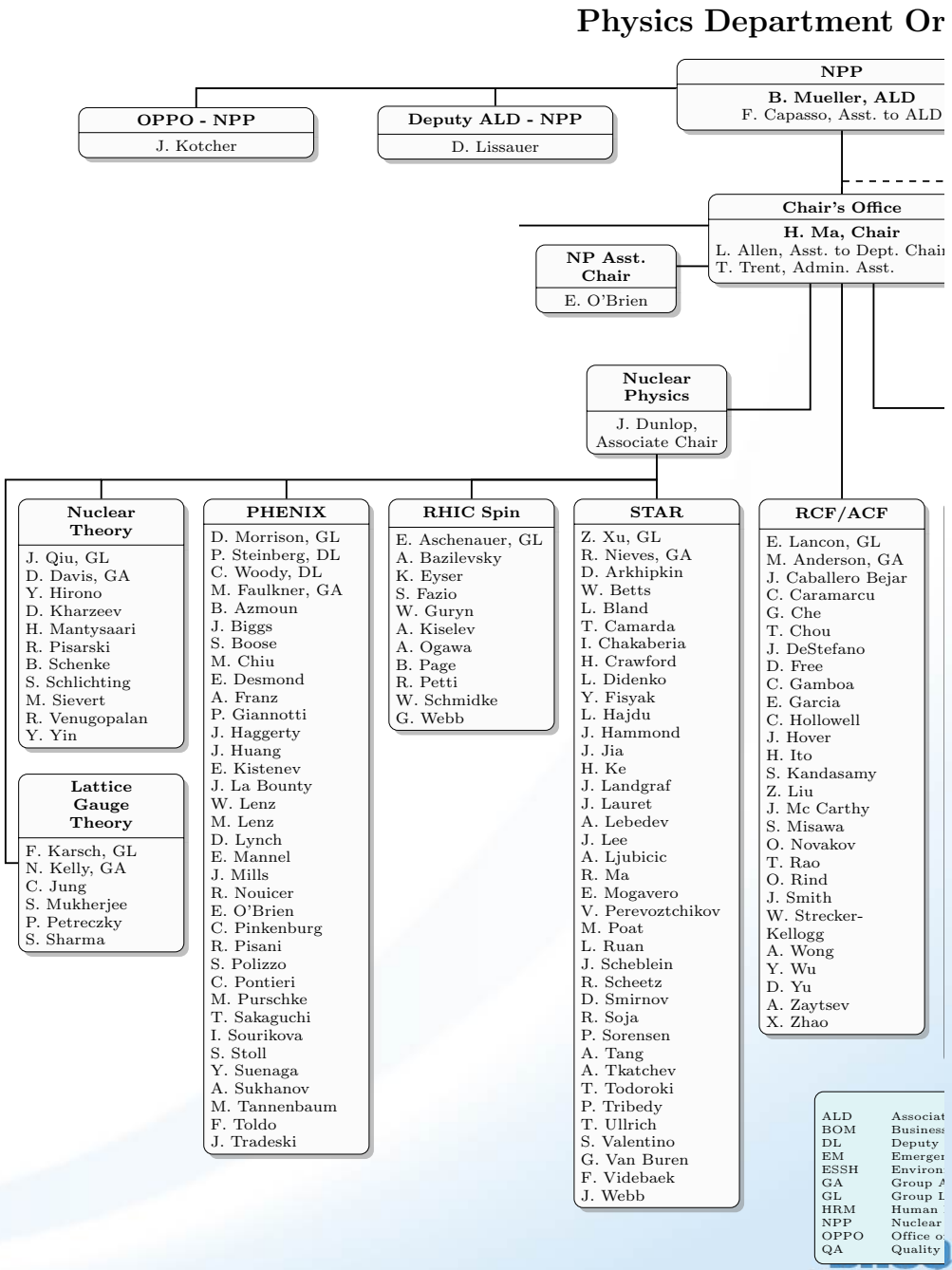
iTPC Upgrade: Schedule

- Project: Milestones from Feb 2016 – March 2019
  - Commissioning run of partial installation FY2018
  - Finish installation prior to FY2019 RHIC Run
- External schedule risk: development of SAMPA chip for ALICE
  - Response Feb, 2016: if necessary, can install previous electronics in half the padrows in FY19, followed by full installation in FY20
    - Loss of acceptance for kurtosis measurements in FY19 only

DOE Technical, Cost, Schedule and Management Review 9/2016

- In light of Detector Task Force Recommendations
  - Commissioning of a partially installed detector in Run 18
  - Modifications of offline software framework already in place for simulations for the proposal; further changes to offline/online to be implemented during Run 18 commissioning
  - All changes to running detector firmware will be archived, and full regression suite developed. Online tracking via High Level Trigger useful here for real-time response.

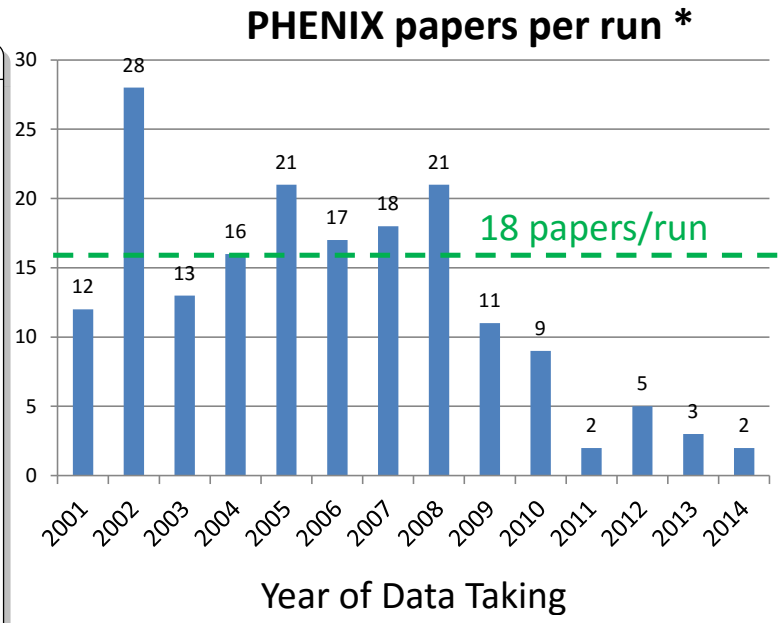
Physics Department Organization related to NP



Transition to sPHENIX

PHENIX

D. Morrison, GL
P. Steinberg, DL
C. Woody, DL
M. Faulkner, GA
B. Azmoun
J. Biggs
S. Boose
M. Chiu
E. Desmond
A. Franz
P. Giannotti
J. Haggerty
J. Huang
E. Kistenev
J. La Bounty
W. Lenz
M. Lenz
D. Lynch
E. Mannel
J. Mills
R. Nouicer
E. O'Brien
C. Pinkenburg
R. Pisani
S. Polizzo
C. Pontieri
M. Purschke
T. Sakaguchi
I. Sourikova
S. Stoll
Y. Suenaga
A. Sukhanov
M. Tannenbaum
F. Toldo
J. Tradeski



(* As of end of 2015 including submitted papers)

Expect >5 years to finish publication of results

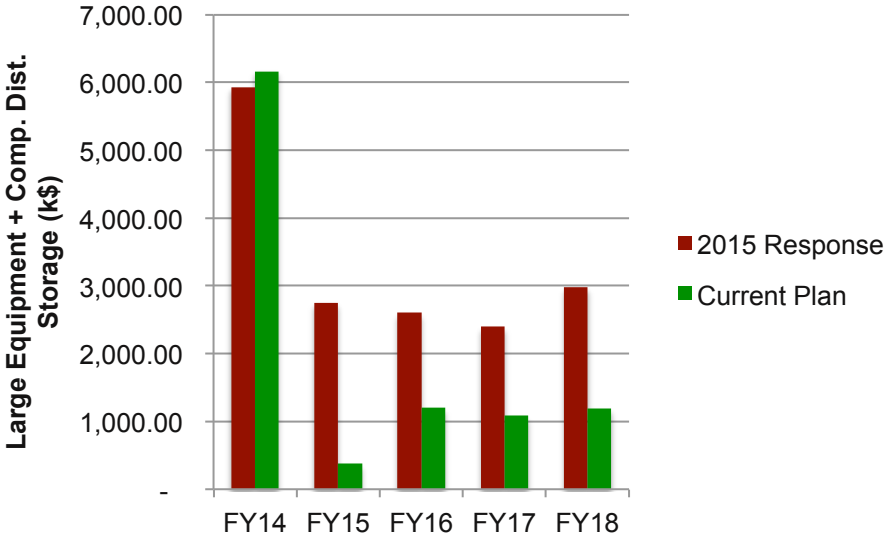
Ongoing PHENIX tasks

- Removal and repurposing has begun: 7/16 – 9/18
- Production of PHENIX data expected to last until 2018
- Publication of data will extend beyond that

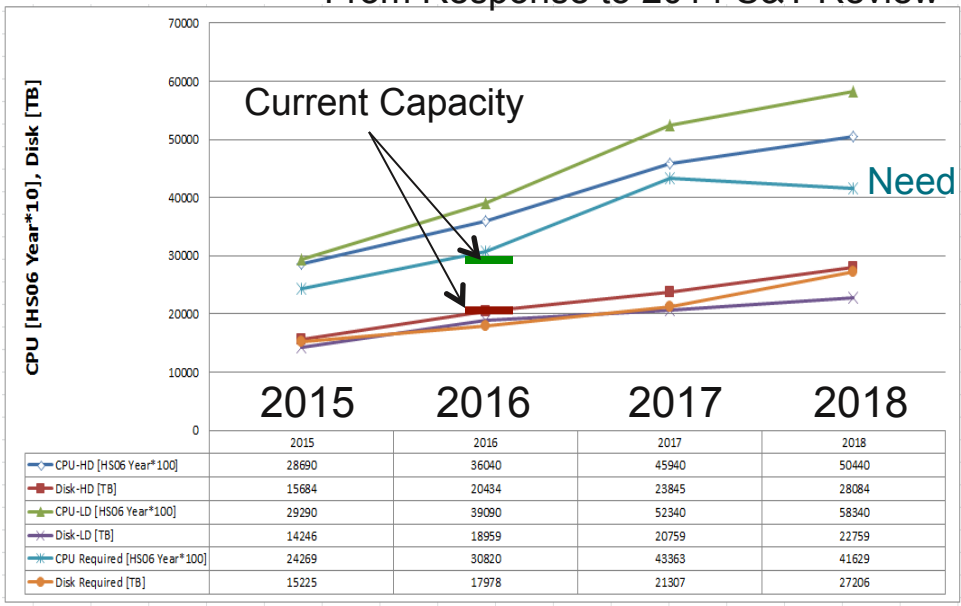
Nearly all in PHENIX group have key role in PHENIX R&R and in work towards sPHENIX

- M. Tannenbaum: ongoing analysis of PHENIX data
- P. Steinberg: ATLAS Heavy Ions

Data Backlog: Challenges



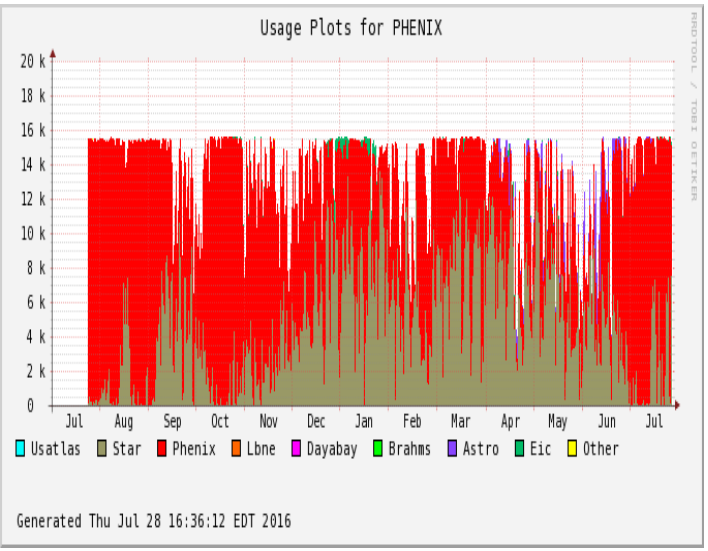
From Response to 2014 S&T Review

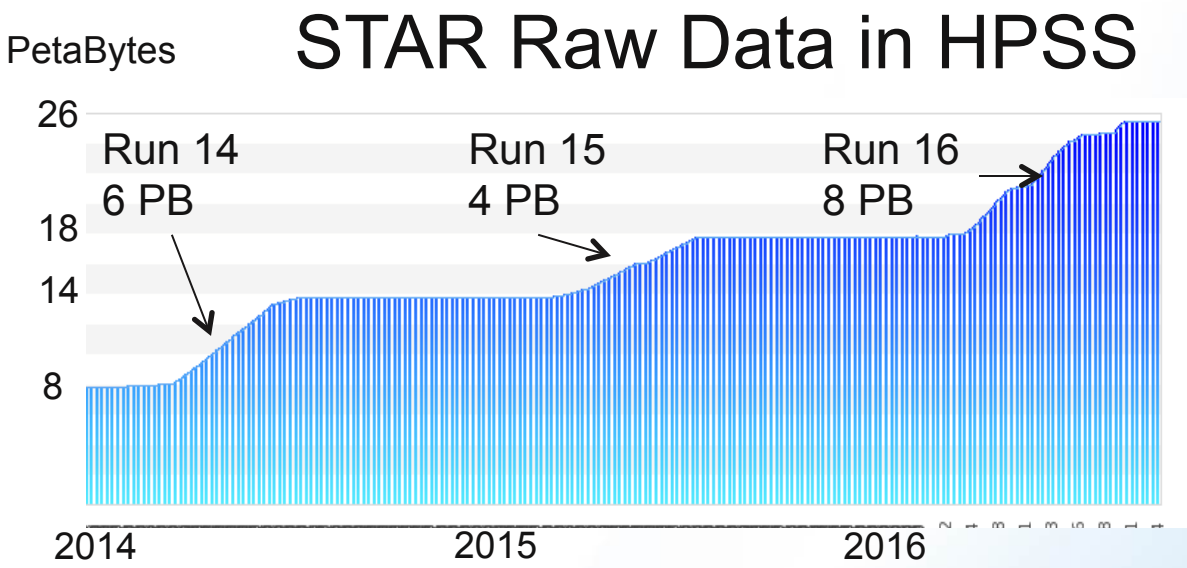


	2015	2016	2017	2018
CPU-HD [HS06 Year*100]	28690	36040	45940	50440
Disk-HD [TB]	15684	20434	23845	28084
CPU-LD [HS06 Year*100]	29290	39090	52340	58340
Disk-LD [TB]	14246	18959	20759	22759
CPU Required [HS06 Year*100]	24269	30820	43363	41629
Disk Required [TB]	15225	17978	21307	27206

- Responded to previous S&T review recommendation: Jan 2015
  - Identified needs and strategies: ~doubling of capacity by 2017
  - **Not possible** under budget scenarios commensurate with upgrades
  - Have met minimum with slowed replacements until now. Not in 2017.
    - Note: Runs 17 and 18 have been added since 2015 report
      - Run 17 was an off year, Run 18 was the beginning of BES-2 and so small
      - Additional data load in 2018 and 2019

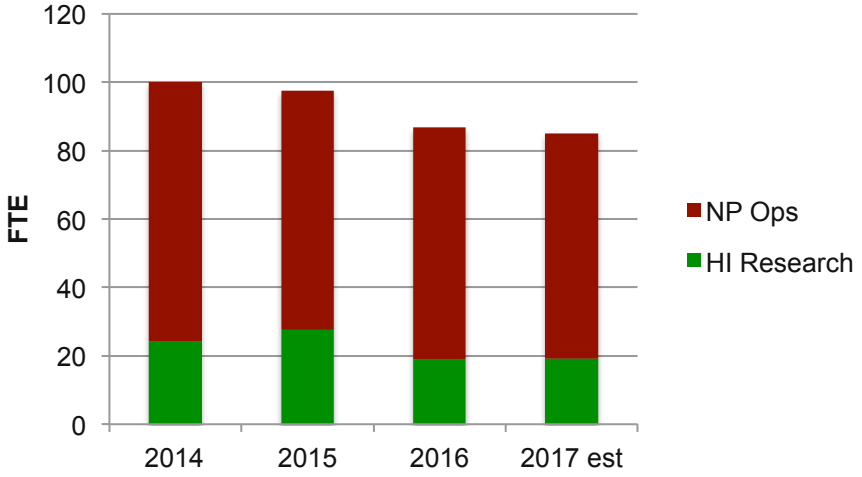
Data backlog: strategies

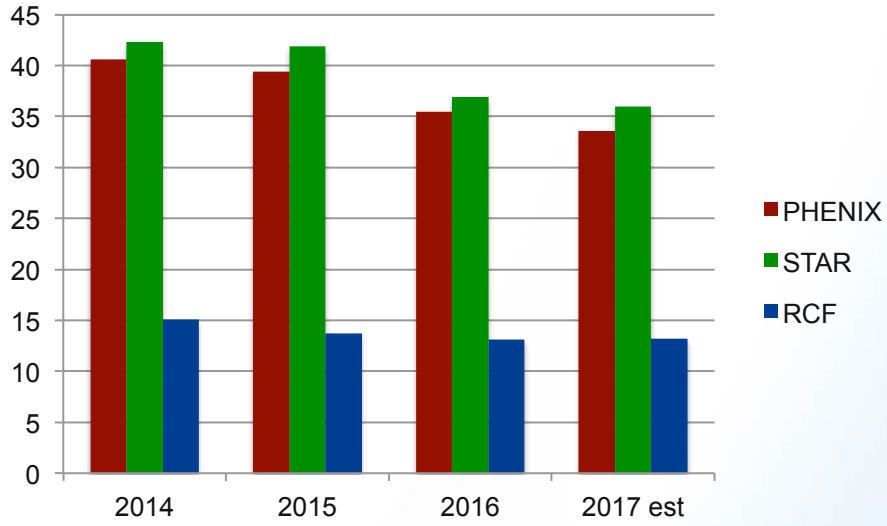




- Challenge to match STAR's computing needs before BES-II
  - Enabled: Opportunistic sharing of PHENIX computing resources
    - Partially successful, but still some issues in full utilization
  - Currently a task force to optimize, expect report in Sept.
  - Opportunistic use of Institutional Cluster
  - STAR is working on internal optimization
    - High Level Trigger: funding from China to increase capacity
    - Collaboration reassessment of DST format

Staffing levels





- 15% decrease in staffing FY14-FY16 necessary
- Focus on short- and medium-term future needs of RHIC
  - Preserve highest priority STAR operations and sPHENIX R&D
- End effect is to reduce research strength in specific areas
  - STAR: reduce post-docs and junior staff, reduce effort on EIC
  - PHENIX: reduce analysis of data on tape and collaboration support
  - Nuclear Theory: accept attrition without replacement
  - ATLAS: reduce effort on analysis

Summary

- Upgrades drive the success of the RHIC program
  - String of final and first results come out this year
  - Dataset goals fully complete for many of the detector systems
    - Many systems in process of removal to optimize future measurements
  - Analysis continuing to reap full benefit of data taken
- Recent challenges in Run 15
  - Recommendations for future practices
  - Mitigations for physics: redundancy
- Highest priority going forward: BES-II + sPHENIX
  - Impacts of preserving priorities:
    - Staffing reduced: reduce research portfolio and collaboration support
    - Computing investments: increase time to results
  - iTPC reasonable but tight: if needed, reduced capability FY19 only